“Tuning” microalgae for high photosynthesis efficiency

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Los Alamos scientist Richard Sayre of Bioenergy and Biome Sciences (B-11) and his team of researchers have recently developed more efficient microalgae.

Microalgae have large rates of biomass accumulation due to their high photosynthetic efficiencies. This makes them attractive candidates for producing green chemical feedstocks and biofuels, particularly oil-based aviation fuels. However, there remains a technical challenge before microalgae can be a commercially viable alternative to current methods of feedstock and fuel production. More productive algal strains must be identified and developed that out-perform current strains to harvest light energy for biomass production. The team’s work in this area is reported in a paper published in the journal *Algal Research*.

Significance of the research

Photosynthetic efficiencies in microalgae cultures are two to three times lower than their theoretical potential due to differences in the fast rate of light capture and the much slower downstream process of photosynthetic electron transfer and carbon fixation. These bottlenecks dissipate a significant amount of the captured light energy as heat or fluorescence instead of driving the reduction of carbon dioxide to sugars.

Although microalgae with large light-capturing antennae are very efficient at capturing photons, they are not as productive in a dense population. The algae at the surface capture more light energy than they can use for carbon dioxide reduction. They dissipate the excess energy and shade the algae below the surface. In the wild, this gives the surface microalgae a competitive advantage. However, this phenomenon is not efficient in monoculture to produce biomass.

Optimizing the size of the light harvesting antennae for microalgae reduces light energy waste, allowing photons to reach algae below the surface. Photosynthesis can occur more uniformly throughout a culture. These experiments demonstrated the optimum antennae size for maximizing biomass production, as well as which gene to manipulate to produce this antennae size.

Research achievements

By modulating the expression of the gene responsible for the synthesis of Chlorophyll b, the researchers generated algae with different light-harvesting antennae sizes. Cultures of algae with intermediate antennae sizes showed the highest rates of photosynthesis as measured by oxygen production. Under the high light intensities preferred for biomass production, cultures of the algae with intermediate antennae sizes grow more rapidly to higher densities than cultures with larger or smaller antennae.

The research team

The Sayre team works to improve efficiency of algae for biomass production and ensure the safety of large-scale cultivation for the production of renewable fuel sources. The group that optimized the photosynthetic efficiency of microalgae includes Zoee Perrine (Phycal Incorporated), Sangeeta Negi (New Mexico Consortium), and Sayre (B-11 and New Mexico Consortium). The New Mexico Consortium is a nonprofit partnership of the three New Mexico Universities. The Consortium promotes scientific research and education collaborations with the Laboratory, which support the Lab's Energy Security mission area and the Materials for the Future science pillar. The U.S. Air Force Office of Scientific Research and the DOE Office of Basic Energy Sciences-Photosynthetic Antennae Research Center supported different aspects of this research.